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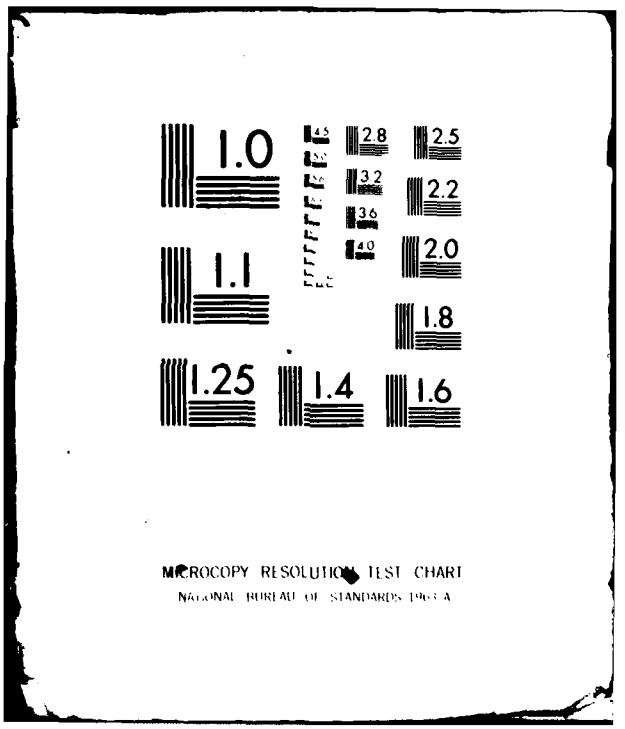
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OPTICAL POWER SPECTRUM ANALYZER

LEVEL II

Scanning Laser Beam System Permits Full Format Coverage

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EASTMAN KODAK COMPANY
Rochester, New York 14650

17 December 1979

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On 18 April 1978, Eastman Kodak Company was awarded a contract to design, fabricate, test, deliver and install an Optical Power Spectrum Analyzer (OPSA). The contract defines a design and fabrication effort intended to draw upon developed technology for its operating principles. This final report therefore deals with the results of final acceptance testing and how the final performance test data compares with initial design requirements.

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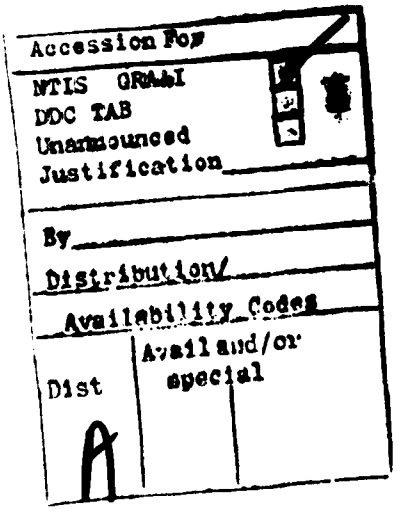
SECTION 1

Summary

On 18 April 1978, Eastman Kodak Company was awarded a contract to design, fabricate, test, deliver and install an Optical Power Spectrum Analyzer (OPSA). On 21 November 1978, the contract was amended to include additional tasks, the major one being the design and fabrication of certain computer interfaces.

The contract defines a design and fabrication effort intended to draw upon developed technology for its operating principles. This final report therefore deals with the results of final acceptance testing and how the final performance test data compares with initial design requirements.



SECTION 2

Introduction

On 18 April 1978, USAETL Procurement Office, Fort Belvoir, Va., 22060, awarded contract number DACA76-78-C-0003 to Eastman Kodak Company. The primary requirements were to design, fabricate, test, deliver and install an Optical Power Spectrum Analyzer (OPSA) in accordance with Eastman Kodak Company's technical proposal dated 22 August 1977. In addition, certain data requirements were specified, of which this report is one.

Subsequently the contract was amended four times to incorporate certain changes in technical requirements, incorporate certain significant additions to the work statement, and to provide such additional funding as was required to successfully carry out this project.

While the hardware which was designed and fabricated represents a somewhat unique approach to power spectrum analysis and attendant large scale data acquisition, the overall design is an assemblage of well proven and reliable approaches. It is to be recognized that certain features and principles have been employed in what may be unique combination, but no research and development effort per se was conducted.

With regard to software, the contract authorized only the generation of software adequate to permit demonstration of the ability of the GFE computer equipment to control the operating functions of the OPSA. This software does not encompass those functions which are necessary to transmit data from the GFE detector electronics to the computer itself. The customer had expressed the desire to accomplish his own suitable programming for data handling.

SECTION 3

Performance Requirements and Acceptance Test Results

All requirements are from Appendix A of Eastman Kodak Company's Technical Proposal for the Coherent Optical Subsystem of the Optical Power Spectrum Analyzer, including revisions incorporated by Amendments Nos. P00001 and P00003.

3.1 Referenced Paragraph of Requirements: 1.1, Laser Source

Requirement:

A He Ne laser is to be incorporated to provide radiation in the TEMoo mode at 632.8 nm. The laser shall operate on 120 VAC, 60 Hz power.

Test Condition:

Since the design of the laser used constrains the operation to the above requirement, no test will be performed.

3.2 Referenced Paragraph of Requirements: 1.2, Intensity Stability

Requirement:

The maximum allowable drift of laser power over 12 hours shall not exceed ±5% from the median.

Test Condition:

The laser will be turned on and the output of the "laser output monitor cell" will be recorded by a suitable chart recorder. The warm-up period required to achieve stability within the tolerances specified will be recorded.

Max. Drift ± 2 %

Stabilizing Period 100 min.

3.3 Referenced Paragraph of Requirements: 1.3, Film Plane Spot Sizes

Requirement:

Spot diameters, as presented at the film plane, shall measure 1.0, 2.0, 4.0, 6.0, 8.0, 10.0 ±0.1mm.

Test Condition:

A UDT PIN 25 photodiode masked with a 100 um pinhole and placed at the film plane will be translated across the spot halted at center scan. The amplified output signal of the cell will be plotted versus the translation of the pinhole on an x-y plotter for each spot size. Copies of these plots will be delivered as the verifying documentation.

See Appendix A for plots.

Spot diameter 0.9 mm
1.9 mm
3.95 mm
5.9 mm
8.1 mm
9.8 mm

3.4 Referenced Paragraph of Requirements: 1.3, Intensity Distribution of 10mm Spot

Requirement:

The distribution of the 10mm beam as presented at the film plane shall be a symmetrical, clipped Gaussian distribution with a maximum center to edge fall off of 50%.

Test Condition:

A UDT PIN 25 photodiode masked with a 100 um pinhole and placed at the film plane will be translated across a diameter of the 10mm spot halted at center scan. The amplified output signal of the cell will be plotted versus the translation of the pinhole on an x-y plotter. Measurements will be made utilizing the plot to verify adherence to the requirement.

Max. Falloff 90 %

3.5 Referenced Paragraph of Requirements: 1.4, Focal Length of Transform Optics

Requirement:

The focal length of the transform optics shall be in the range from 21.5 inches to 25.0 inches.

Test Condition:

The distance from the reflective surface of the galvanometer to the front surface of the first paraboloid will be measured to a precision of 0.1 inch. This will be taken as the focal length of the paraboloid since the theoretical error in doing so amounts to 0.011 inch.

Focal Length 22.6 inches.

3.6 Referenced Paragraph of Requirements: 1.5, Telecentricity

Requirement:

The 6mm spot shall be scanned across a 9.5 inch open gate and the resulting signal deviation on a .007 inch diameter detector placed at the RSI detector plane shall not exceed 4%.

Test Condition:

The 6mm beam will be scanned across an open gate narrowed to 9.5 inches. The signal delivered by the RSI zero order amplifier will be displayed on the vertical axis of an oscilloscope. Since these amplifiers are quite linear (<1% distortion) any voltage deviation displayed on the oscilloscope can be interpreted as the intensity variation on the .007 inch diameter center element of the array. Voltage deviation magnitude will be compared to the median voltage across the scan to confirm adherence to the requirement. A photographic record of the oscilloscope trace will be delivered.

Signal Deviation 5 % *

See Appendix A for Oscilloscope Trace

* The last 6mm of scan on the inboard end show a maximum voltage of approximately 20%, rising from 5% to 20% at the very edge of a 9 1/2 inch scan.

3.7 Referenced Paragraph of Requirements: 1.6, Scan Speed

Requirement:

The scanner frequency and velocity shall be controlled such that contiguous spots at the film plane may be sampled at 3 msec. intervals for all spot diameters provided.

Test Condition:

An oscilloscope will be used to display clock pulses in order to verify 3 msec spacing for each of the eight selectable sample spacings. In order to verify contiguous samples at the film plane, an optical chopper will be introduced into the optical system. The clock pulses will be utilized to gate short pulses of light through the scanning system which in turn will be used to expose red-sensitive film. For each of the seven wider sample spacings it will therefore be possible to verify actual sample spacings by measuring the dot spacings on the film. A 1mm spot diameter will be utilized in each case.

Sample Spacings 1.02 mm
2.05 mm
3.05 mm
4.05 mm
6.05 mm
8.05 mm
10.1 mm

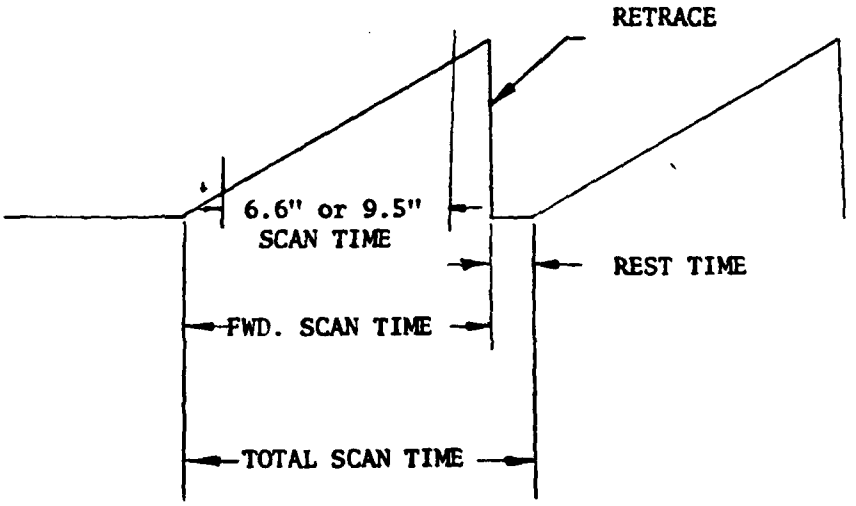
Sample Time Intervals (msec)

Nom. Sample Spacing (mm)	9.5" scan min./max.	6.6" scan min./max.
0.5	2.4/3.1	2.4/3.1
1	2.75/3.2	2.75/2.9
2	2.8/3.2	2.9/3.1
3	2.9/3.25	2.9/3.0
4	2.9/3.3	2.9/3.2
6	2.8/3.2	2.9/3.1
8	2.9/3.3	2.9/3.1
10	2.9/3.3	2.9/3.1

Customer Requested Data.

Rest Time (msec)

Nom. Sample Spacing (mm)	9.5" scan	6.6" scan
(0.5)	(75)	(95)
1	120	80
2	100	70
3	90	75
4	90	75
6	90	75
8	90	75
10	90	80



3.8 Referenced Paragraph of Requirements: 1.7, Film Dimensions

The machine shall be capable of operating with the following film parameters and spools:

9.5" wide, 4 mil film in maximum lengths of 700', 6.6" wide 4 mil film in maximum lengths of 500'. Maximum spool diameter 7 5/8", S-47, S-48, and S-50 spools for 9.5" film. #222 spool for 6.6" film.

Test Condition:

All combinations possible with the above materials will be used during testing. All combinations run successfully will be indicated.

Supply	Takeup	OK
S-47	S-47	✓
S-47	S-48	✓
S-47	S-50	✓
S-48	S-47	✓
S-48	S-48	✓
S-48	S-50	✓
S-50	S-47	✓
S-50	S-48	✓
S-50	S-50	✓
#222	#222	✓

3.9 Referenced Paragraph of Requirements: 1.8, Film Transport

Requirement:

The following capabilities shall be present on the machine.

a. Manual bidirectional film slew 0 - 120 fpm Fwd. = 116 fpm
Rev. = 116 fpm

b. Computer controlled bidirectional film slew 0 - 120 fpm
Fwd. = 114 fpm
Rev. = 115.5 fpm

c. Minimum accuracy of locating a given cross-track frame coordinate shall be ±1.0mm. ±.67mm at 10mm spacing

d. The film length counter shall be accurate to ±0.2%.
+.13%

3.10 Referenced Paragraph of Requirements: 1.10, Optical Table

Requirement:

The OPSA structure shall be constructed utilizing vibration isolation techniques suitable for coherent optical systems.

Test Condition:

By design the air bag suspension system utilized in the OPSA structure, when properly inflated, will pass only those vibrations of 4 or 5 Hz to the structure. These frequencies are far removed from any resonant frequency in the structure or mounts and will therefore not result in any detectable anomalies. No test will therefore be performed.

3.11 Referenced Paragraph of Requirements: 1.11, Light Tightness and Shrouding

Requirement:

With all shrouds in place, the allowable level of illumination resulting from room light leakage into the system shall be less than or equal to the dark current of the various detectors.

Test Condition:

With all shrouds in place, both lasers turned off and with room lights off, the front panel readout of both "laser power" and "film plane intensity" monitor cells will be recorded. Any changes in these readings when the room lights are turned on will be recorded. Since all of these cells are operated in the photovoltaic mode, any change recorded will have to be translated into equivalent current in order to compare it with the rated dark current. Random segments of the RSI detector will be read in the same manner before and after the room lights are lit. Similarly, any variations of output will be translated to current.

Readings, Laser Monitor 0
Film Plane Monitor 0
RSI "0" Order 0
RSI #34 Cell 62% of dark current

3.12 Referenced Paragraph of Requirements: 1.12, Size and Weight

Requirement:

System components shall be able to pass through a 33 1/2 x 79 1/2 inch door and must not exceed 8,000 lbs.

Test Condition:

Overall system measurements, as well as an approximate component weight will be recorded.

	OPSA	Computer	Line Printer
Height	73 1/4 in	64 3/8 in	38 in
Width	61 5/8 in	42 1/4 in	26 3/4 in
Depth	33 in	32 1/4 in	21 3/4 in
Weight	2500 lbs (est.)	470 lbs (est.)	100 lbs (est.)

3.13 Referenced Paragraph of Requirements: 2.9, Instruction Plates

Requirement:

Instruction plates and warning labels shall be applied describing any special procedures to be followed in servicing or operating.

Test Condition:

The following check list will be utilized to ensure that proper labels are applied:

Electrical data plate ✓

Threading diagram ✓

Spot size change instruction plate ✓

High voltage warnings ✓

Laser radiation warnings ✓

Caution-exposed optical surfaces ✓

3.14 Computer Interface - Amendment P00001, Paragraph 2.1

Requirement:

The interface design shall provide computer control of, or monitor the following signals. Each will be demonstrated functionally.

Monitor clock pulse count per scan and end-of-scan function ✓

Control transport (scan and slew) ✓

Control sample spacing (in and cross-track) ✓

Film width setup ✓

Monitor laser power ✓

Read film length ✓

Read frame counter ✓

Read frame mark detector ✓

Monitor spot size ✓

Interrupt monitor: Frame Mark ✓

Clock ✓

3.15 Spot Size Display - Amendment P00001, Paragraph 2.3

Requirement:

A digital display shall be provided on the control panel to indicate the spot diameter, in mm, currently in use.

Test Condition:

The spot size display will be demonstrated functionally ✓

3.16 Automatic Optical Beam Alignment - Amendment P00001, Paragraph 2.4

Requirement:

The alignment device shall allow rapid, accurate realignment of the optical system necessitated by perturbations encountered in spot size changeover. Any signals which exceed the range of either the piezoelectric drivers or the error signal amplifier must be readily correctable through utilization of the precision alignment micrometers and the error signal meters.

Test Condition:

With the 6mm beam properly aligned and scanning 9.5 inches, the RSI zero order signal will be displayed on an oscilloscope. The turret will then be rotated through several beam position detents in succession. The alignment will be corrected as necessary at each position utilizing the alignment micrometers and error signal meters. Upon return to the 6mm turret position, the alignment will once more be corrected as necessary to null the error signals as indicated on the meters. The telecentricity requirement must be satisfied without any further adjustment. Photographs of the oscilloscope traces will be included in the Appendix as the verifying document.

3.17 Beam Attenuator - Amendment P00001, Paragraph 2.5

Requirement:

The attenuator shall contain a minimum of nine inconel neutral densities ranging from approximately 0.0D to 1.0D in approximately 0.125 D steps. Operation must be by means of a detented knob on the front of the machine. A dial around the knob will indicate the attenuator positions.

Test Condition:

Each of the densities will be introduced into the beam in sequence. In each case the "film plane intensity" meter will be read. Actual densities will be calculated and rounded to nearest 0.005.

Densities 0.070
0.210
0.370
0.420
0.520
0.660
0.755
0.900

SECTION IV

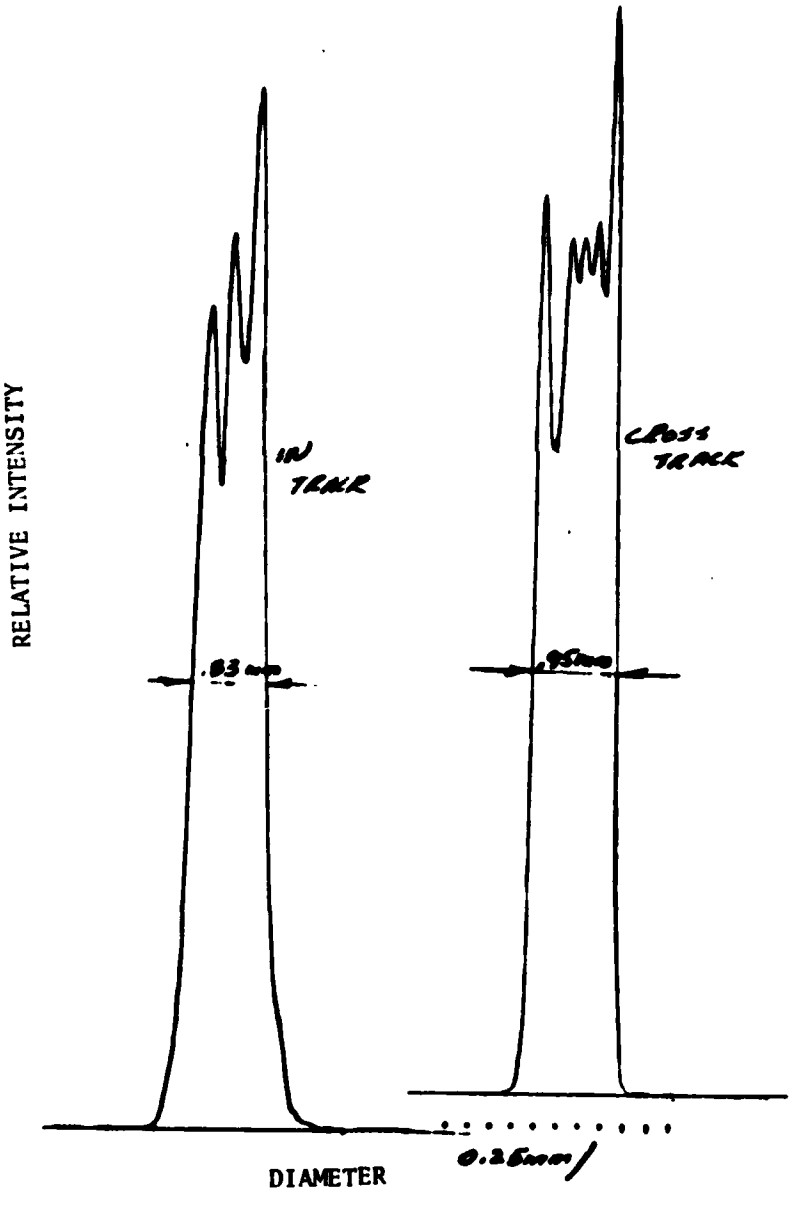
Recommendations

The OPSA is a highly sophisticated system designed specifically to be highly sensitive to light energy which has become diffracted at or near the film plane. However, it also will be sensitive to energy which becomes diffracted or scattered from certain critical optical surfaces. Improper cleaning procedures can degrade these surfaces to the extent that spuriously diffracted light may be detected as unwanted signal or noise. Since the bona fide signal levels can be extremely low, it is possible that they could be smothered and unreadable. It is strongly recommended, therefore, that cleaning procedures delineated in the Operation and Maintenance Manual be followed most carefully.

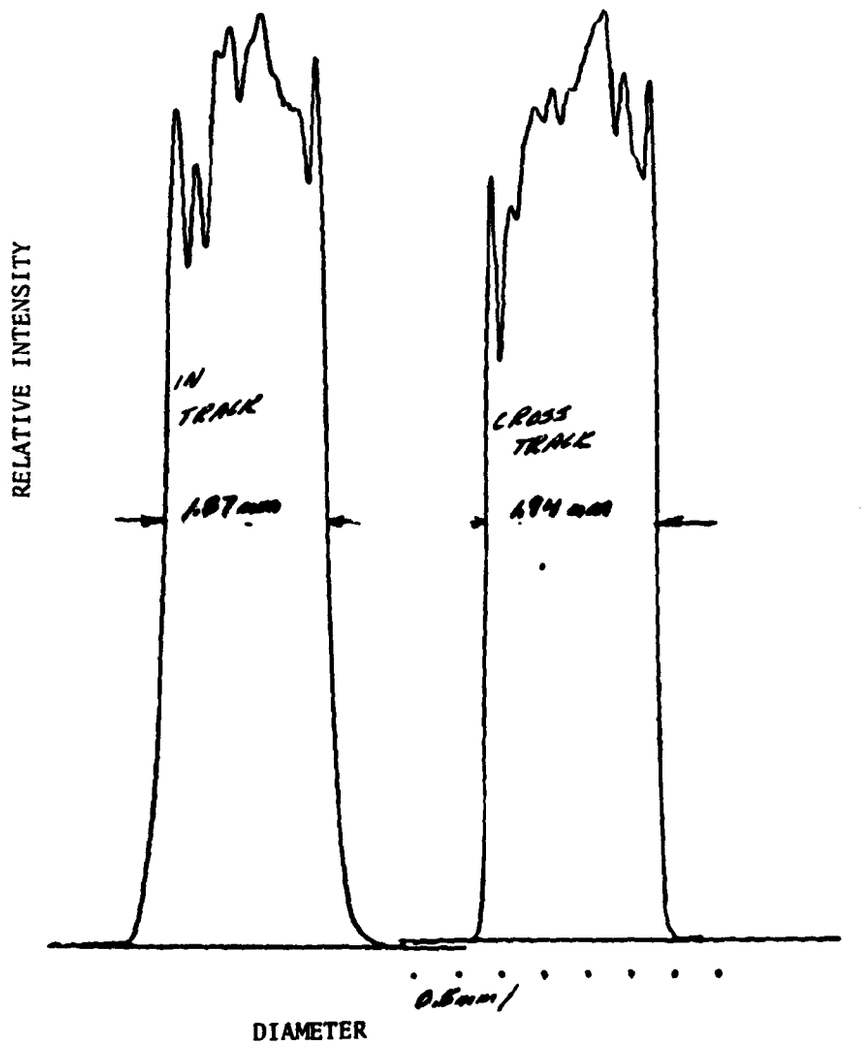
APPENDIX A

Pages 17 thru 22 are the plots of relative intensity vs. distance along in-track and cross-track diameters for each spot size from 1 thru 10mm. The diameters shown are measured at the 50% of max. intensity point, and the data given in paragraph 3.3 is the average of the in-track and cross-track diameters. The data for paragraph 3.4 is taken from the plot for the 10mm spot.

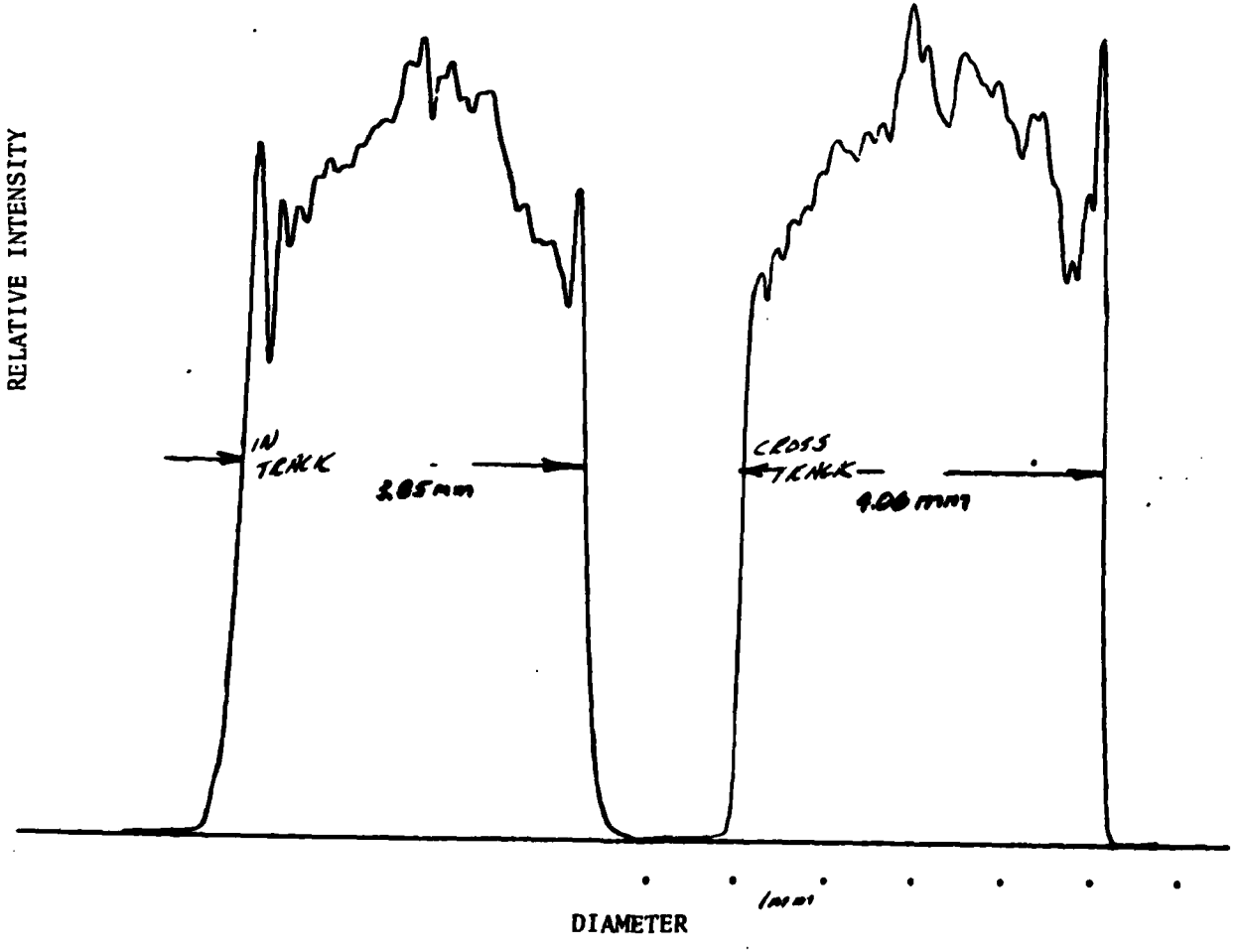
1mm BEAM
NB/4 S:N/DC3



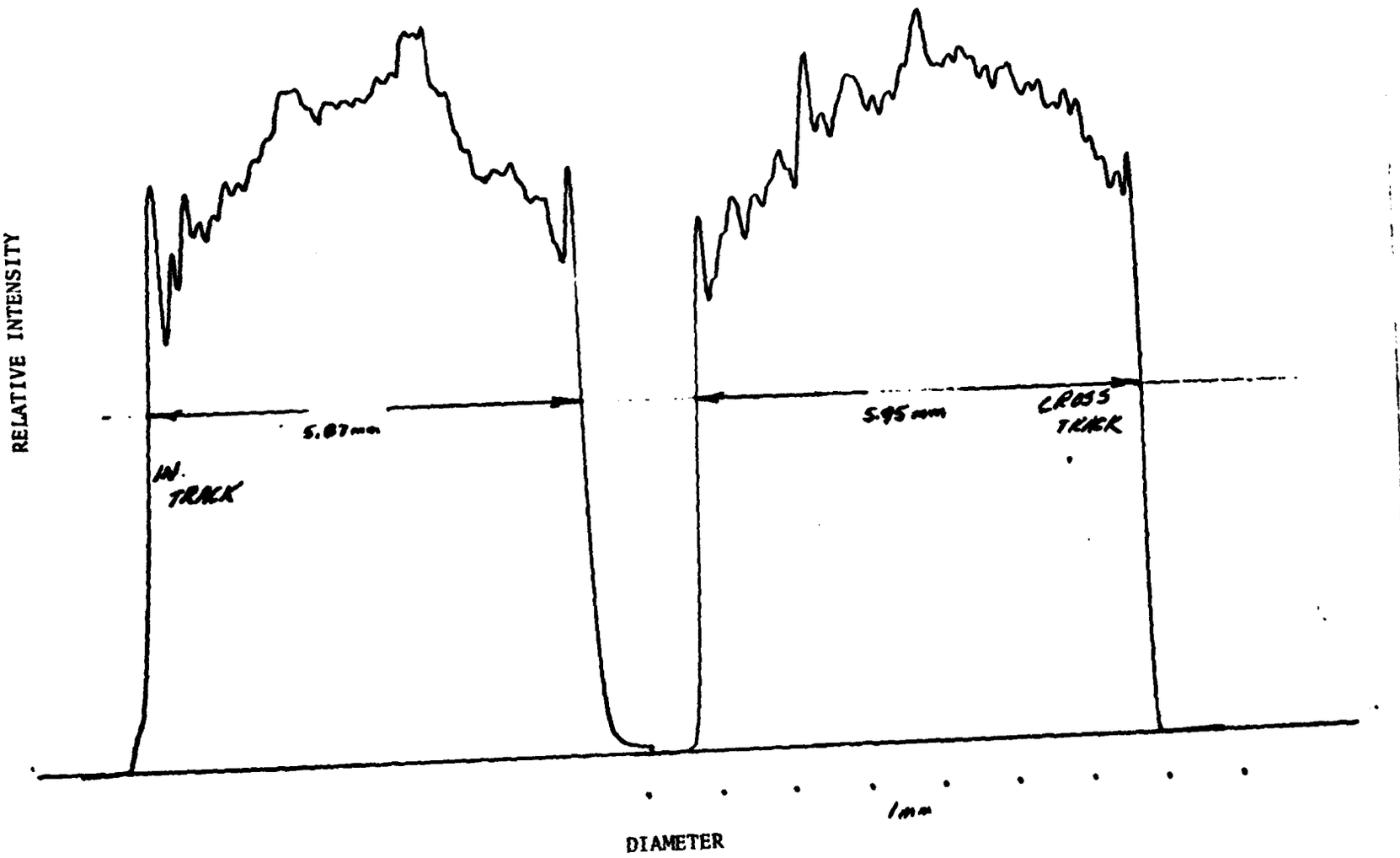
2mm BEAM
12/4 SCH/D-13



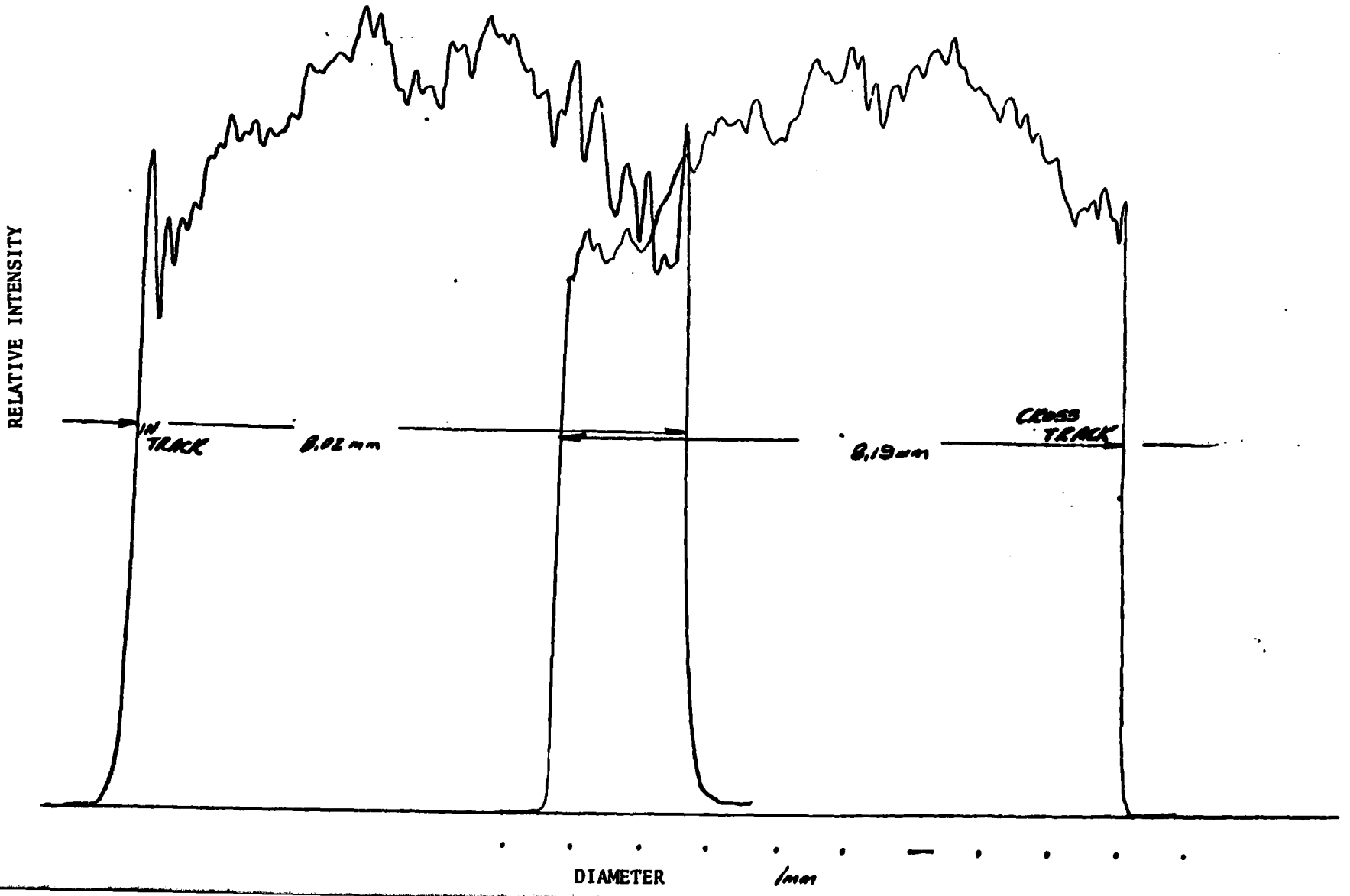
4mm BEAM
12/6 SCA/DKB



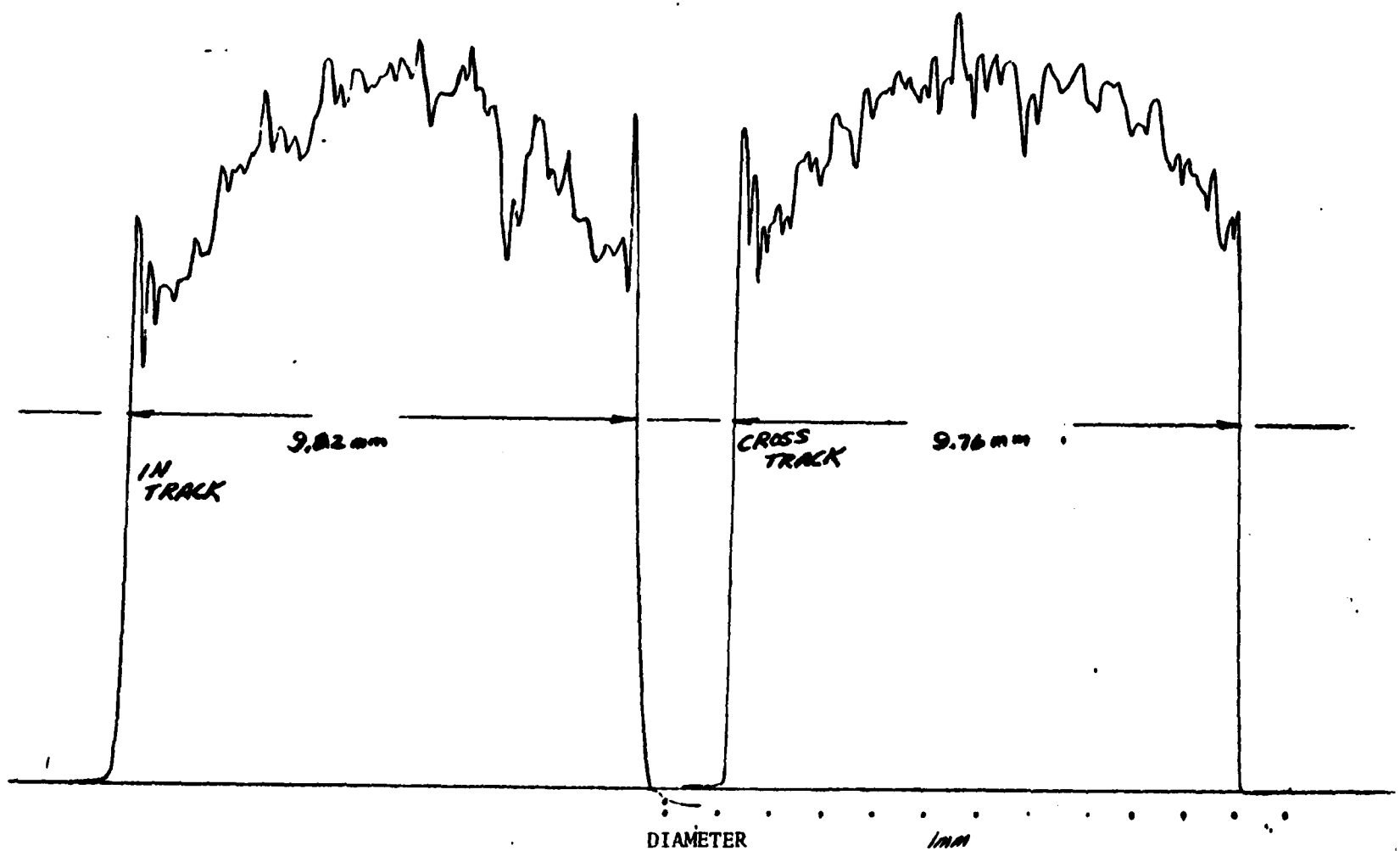
6mm BEAM
12/6 SCM/DCB



8mm BEAM
12/4 x N/10



10mm BEAM
R/A 5K0/1K8



APPENDIX B

The accompanying photographs illustrate the signal level of the RSI zero order element (.007 in. dia.) as the 6mm diameter beam scans across the 9.5 inch gate. Superimposed on the signal level variation is 60 cycle ripple present in the laser beam (2.3% amplitude).

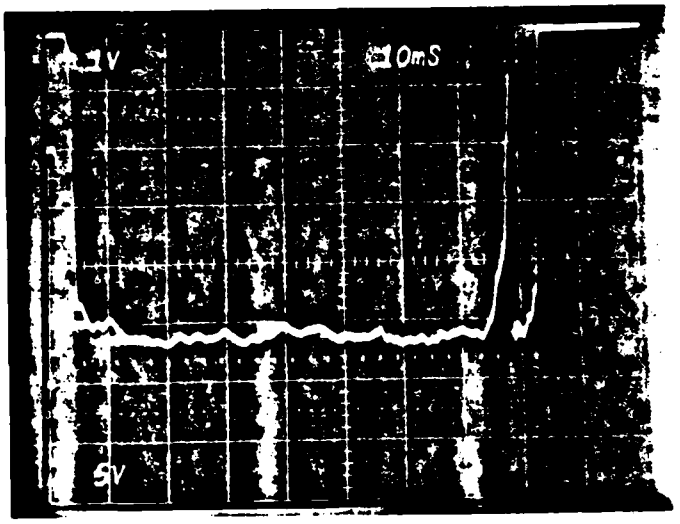


Fig. 1. Single scan of 6mm beam across 9.5 inches illustrating level of telecentricity. Ref. para. 3.6

Fig. 2. Telecentricity prior to execution of para. 3.16

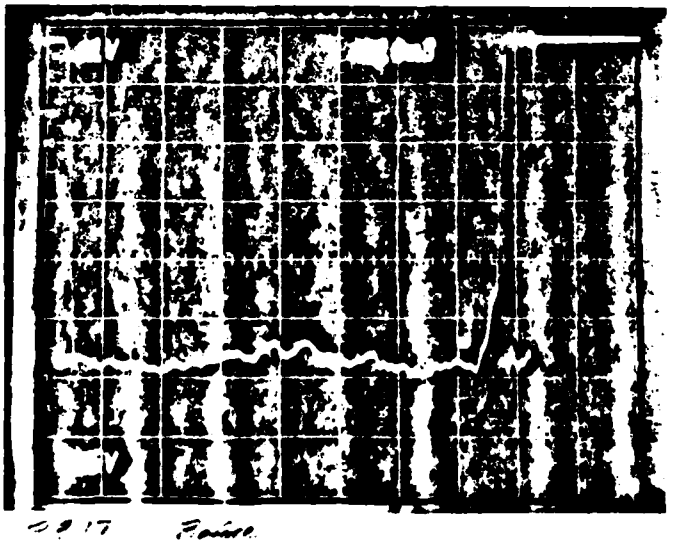
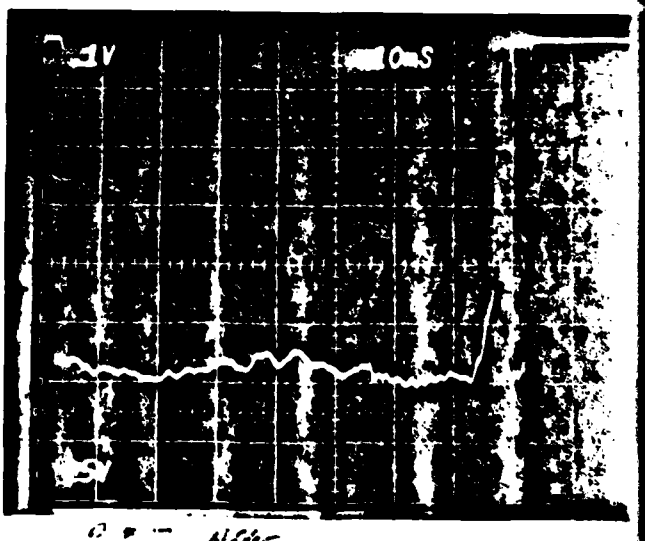
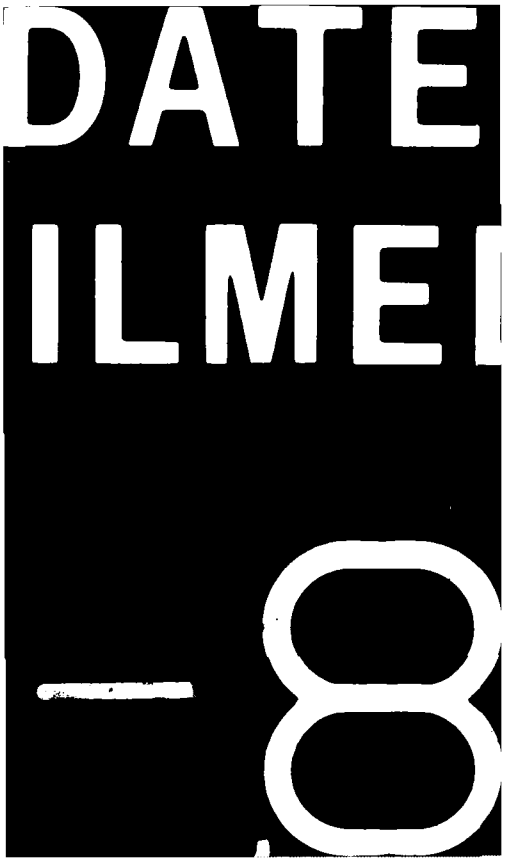


Fig. 3. Telecentricity following execution of para. 3.16

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